Base from U.S. Geological Survey, 1955



SCALE 1:250 000

CONTOUR INTERVAL 200 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

Map B .-- Copper, lead, zinc, and molybdenum in heavy-mineral concentrate

samples, Mount Hayes quadrangle, Alaska.

Unconformity Tsc Unconformity Intrusive contact lgs Intrusive contact Intrusive contact jes Hayes Glacier subterrane South of Hines Creek and Mount Gakona faults **AURORA PEAK TERRANE** South of Nenana Glacier fault and north of Denali fault CRETACEOUS WINDY TERRANE Within splays of Denali fault SEDIMENTARY, VOLCANIC, AND METAMORPHOSED SEDIMENTARY, VOLCANIC, AND PLUTONIC ROCKS South of Denali fault ULTRAMAFIC AND ASSOCIATED ROCKS Splay of Denali fault MACLAREN TERRANE South of Denali fault and north of Broxson Gulch thrust East Susitna batholith and schist, quartzite, and amphibolite South of Denali fault and north of Meteor Peak fault TERTIARY AND CRETACEOUS OR OLDER mig CRETACEOUS(?) mgsh Intrusive contact sq Maclaren Glacier metamorphic belt South of Meteor Peak fault OR OLDER CLEARWATER TERRANE Within splays of Broxson Gulch thrust WRANGELLIA TERRANE South of Denali fault and Broxson Gulch thrust Tsv Disconformity Ts

Unconformity

AND TRIASSIC

TRIASSIC

TRIASSIC(?)

CRETACEOUS

AND JURASSIC

PERMIAN AND

PENNSYLVANIAN

PENNSYLVANIAN

JRm

cu

Intrusive contact

KJs

Disconformity

Intrusive contact

Rnf

Rnp

Disconformity

EXPLANATION OF GEOCHEMICAL SYMBOLS FOR MAPS A AND B

range on tables 1 through 8.

Geology (generalized) mapped by W.J. Nokleberg, I.M. Lange, J.N. Aleinikoff, R.T. Miyaoka, C.E. Schwab, and R.E. Zehner, 1977-1985.

Pzt

Tangle subterrane

South of Eureka Creek fault

PALEOZOIC

ONLY ONE OF THE SELECTED

CLUSTER OF DRAINAGE BASINS

REFERRED TO IN TEXT

o SAMPLE SITE

Slana River subterrane South of Denali fault and Broxson Gulch thrust and north of Eureka Creek fault

OR OLDER

DEVONIAN

DEVONIAN

OR OLDER

SILURIAN

SILURIAN(?)

CORRELATION OF MAP UNITS DESCRIPTION OF MAP UNITS QUATERNARY Surficial deposits (Quaternary) -- Alluvium, colluvial deposits, glacial deposits, fluviolacustrine deposits, rock glacier deposits, snow, and ice Granitic plutonic rocks (early Tertiary? to Late Jurassic)-Medium- to coarse-grained biotite-hornblende granite and SEDIMENTARY AND IGNEOUS ROCKS hornblende-biotite granodiorite, with lesser quartz diorite North of Denali fault and diorite and sparse monzonite. Forms moderate to large plutons and sparse dikes. Locally schistose and recrystallized at lower greenschist facies. Individual plutons generally fault bounded in area south of Denali fault. Local intense hydrothermal alteration SEDIMENTARY AND IGNEOUS ROCKS TERTIARY(?) AND North of Denali fault CRETACEOUS Sandstone, conglomerate, and coal (middle or early Tertiary)-Conglomerate at the base grading upward into interbedded sandstone and coal. Overlain by interbedded lenses of poorly consolidated siltstone, mudstone, and sparse YUKON-TANANA TERRANE sandstone. Includes locally extensive coal deposits in Lake George subterrane vicinity of Jarvis Creek North of Tanana River fault Lamprophyre and alkalic gabbro (early Tertiary)-Panidiomorphic-granular aggregates of olivine, MISSISSIPPIAN orthopyroxene, clinopyroxene, hornblende, biotite, plagioclase, and potassium feldspar containing various amounts of groundmass (fine-grained hornblende, biotite, plagioclase, and opaque minerals), and interstitial or replacement carbonate; local embayed phenocrysts. Occur in small- to moderate-size plutons and dike swarms OR OLDER Monzonite and monzodiorite (early Tertiary)--Hypautomorphic Macomb subterrane aggregates of clinopyroxene, biotite, potassium feldspar, South of Tanana River fault olagioclase. Local white mica and carbonate alteration. Forms moderate-size plutons as part of intrusive complex with lamprophyre and alkalic gabbro in north-central part DEVONIAN Gabbro and mafic plutonic rocks (Tertiary? and Cretaceous)-OR OLDER Gabbro and metagabbro with lesser diabase, varying from mainly hypautomorphic-granular or ophitic aggregates of hornblende, plagioclase, and lesser biotite to metagabbro Jarvis Creek Glacier subterrane composed of schistose aggregates of actinolite, chlorite South of Elting Creek fault biotite, epidote, and albite. Occur in narrow dikes to small to moderate-size plutons DEVONIAN YUKON-TANANA TERRANE

Lake George subterrane North of Tanana River fault Augen gneiss and schist (Mississippian)--Coarse- to medium-

grained augen gneiss and schist composed of schistose aggregates of potassium feldspar, plagioclase, biotite, and quartz. Ductilely deformed and regionally metamorphosed at amphibolite facies into mylonitic gneiss and schist. Occurs in moderate- to large-size, irregularly shaped, homogeneous plutons intruding schistose granitic plutons and pelitic schist. Relict hypautomorphic-granular texture with relict potassium feldspar phenocrysts. Locally deformed and retrograded to lower greenschist facies Medium-grained gneissose granitic rocks (Devonian)--Gneissose

hornblende-biotite granodiorite and lesser gneissose biotite granite. Relict hypautomorphic-granular texture. Occurs plutons intruding pelitic schist. Ductilely deformed and regionally metamorphosed at amphibolite facies into mylonitic gneiss. Locally deformed and retrograded to the lower greenschist facies

Coarse-grained pelitic schist (Devonian or older)--Polydeformed, coarse-grained, pelitic muscovite-quartzbiotite-garnet schist derived from quartz-rich to clay-rich shale. Ductilely deformed and regionally metamorphosed at amphibolite facies into mylonitic schist. Locally deformed and retrograded to the lower greenschist facies

> Macomb subterrane South of Tanana River fault

Metamorphosed granitic rocks (Devonian)--Fine- to mediumgrained gneissose granite and granodiorite with lesser quartz diorite and diorite. Ductilely deformed and regionally metamorphosed into mylonitic gneiss at epidoteamphibolite facies. Forms irregularly shaped plutons and dikes intruding pelitic schist, calc-schist, and quartzfeldspar schist. Locally deformed and retrograded to lower greenschist facies

Metamorphosed pelitic, calcareous, and quartz-feldspar sedimentary rocks (Devonian or older) -- Medium-grained, polydeformed, biotite-muscovite-quartz pelitic schist, garnet-plagioclase schist, and quartz-plagioclase-biotite schist derived from shale, marl, and sandstone. Ductilely deformed and regionally metamorphosed at epidote-amphibolite facies into fine- to medium-grained mylonitic schist. Locally deformed and retrograded to lower greenschist facies

Jarvis Creek Glacier subterrane South of Elting Creek fault

Fine- to medium-grained gneissose diorite, granodiorite, and granite (Devonian)--Gneissose hornblende-biotite diorite and granodiorite and lesser augen gneiss or schistose granite. Occurs in small to moderate-sized, irregularly shaped, homogeneous plutons. Relict hypautomorphic granular texture. Mainly in Donnelly Dome and benchmark Ober areas intruding pelitic schist and quartzite. Ductilely deformed and regionally metamorphosed at amphibolite facies into mylonitic gneiss and schist. Locally retrograded to lower greenschist facies to the south

Fine-grained schistose volcanic rocks and pelitic schist

(Devonian) -- Polydeformed, fine-grained, schistose metaandesite and metaquartz keratophyre with lesser metadacite, metabasalt, pelitic schist, quartzite, calcschist, and marble. Ductilely deformed and regionally metamorphosed at greenschist facies into mylonitic schist or local phyllonite. Local intense iron staining, and disseminated and massive-sulfide minerals

Fine-grained pelitic schist and quartzite (Devonian or older)--Polydeformed, fine-grained pelitic schist and quartzite with lesser calc-schist, quartz-feldspar schist and marble, and with very sparse schistose metavolcanic rocks. Metasedimentary rocks derived from shale, chert or quartz sandstone, marl, volcanic graywacke, and limestone. Ductilely deformed and regionally metamorphosed a greenschist facies into mylonitic schist or local phyllonite. Includes large areas of upper green-schist facies and lower amphibolite facies metamorphic rocks in the area south of Granite Mountain and south of Donnelly Dome. Amphibolite facies minerals to the north are progressively replaced by greenschist-facies minerals to the south

Hayes Glacier subterrane South of Hines Creek and Mount Gakona faults

Fine-grained schistose volcanic rocks and phyllite (Devonian)--Polydeformed, schistose to phyllitic meta-andesite and metaquartz keratophyre, and lesser metadacite and metabasalt with locally abundant pelitic phyllite, quartz phyllite, and calc-phyllite. Ductilely deformed and regionally metamorphosed at lower and middle greenschist facies into phyllonite and blastomylonite. Includes some areas of iron staining and disseminated sulfide minerals

Fine-grained schistose sedimentary rocks (Devonian or older)--

Pelitic phyllite, quartz phyllite, and calc-phyllite. In eastern part of quadrangle, chiefly polydeformed quartzchlorite-white mica phyllite, graphitic-quartz phyllite, quartz-plagioclase phyllite, calc-phyllite, and marble. Locally meta-andesite, metaquartz keratophyre, and metadacite. In western part of quadrangle, chiefly polydeformed pelitic schist, quartz-mica schist, and lesser siltstone and sandstone, and marble. Derived from shale chert or quartz siltstone, volcanic graywacke, marl, and limestone. Ductilely deformed and regionally metamorphosed at lower and middle greenschist facies into phyllonite and blastomylonite

AURORA PEAK TERRANE South of Nenana Glacier fault and north of Denali fault Metamorphosed gabbro, quartz diorite, granodiorite, and granite (Late Cretaceous)--Regionally metamorphosed

utonic rocks consisting of gneissose gabbro, quartz

diorite, granodiorite, and granite; and amphibolite derived from gabbro and diorite. Occurs in east-striking plutons and dikes intruding calc-schist, marble, quartzite, and pelitic schist. Relict hypautomorphic granular texture. Ductilely metamorphosed and deformed twice, once into mylonitic schist during an earlier period of upper amphibolite facies metamorphism, and later into blastomylonite during a period of middle greenschist-facies

Metamorphosed calcareous, quartzose, and pelitic sedimentary rocks (Triassic to Silurian)--Polydeformed, fine- to medium-grained calc-schist, marble, quartzite, and pelitic schist. Derived from marl, quartzite, and shale. Ductilely metamorphosed and deformed twice, once into mylonitic schist during an older period of upper amphibolite facies metamorphism and later into blastomylonite at middle greenschist facies

WINDY TERRANE

metamorphism

Within splays of Denali fault Argillite, siltstone, graywacke, and limestone (Devonian and Silurian?)--Weakly metamorphosed argillite, quartz-pebble siltstone, quartz sandstone, graywacke, conglomerate, limestone, and marl; lesser andesite and dacite. Local weak schistosity. Intensely deformed locally, with development of phyllonite and protomylonite in narrow shear zones. Exhibits incipient lower greenschist-facies

SEDIMENTARY AND VOLCANIC ROCKS AND METAMORPHOSED SEDIMENTARY, VOLCANIC, AND PLUTONIC ROCKS South of Denali fault

TERRANE OF ULTRAMAFIC AND ASSOCIATED ROCKS Pyroxenite, peridotite, dunite, and amphibolite (Mesozoic?)--Partly serpentinized. Lesser hornblende-plagioclase gneiss, and minor serpentinite, marble, graphitic schist, tonalite, and granite. Earlier pervasive ductile deformation and metamorphism at amphibolite facies. Locally well defined schistosity. Later locally intensely

MACLAREN TERRANE South of Denali fault and north of Broxson Gulch thrust East Susitna batholith and schist, quartzite, and amphibolite

deformed and metamorphosed to lower greenschist facies

South of Denali fault and north of Meteor Peak fault Gneissose granitic rocks (early Tertiary and Late Cretaceous)--Polydeformed quartz diorite and granodiorite, with lesser granite. Relict hypautomorphic-granular texture. Regionally metamorphosed and ductilely deformed at middle amphibolite facies into mylonitic gneiss. Grade into migmatite, migmatitic schist, schist, and amphibolite. Local retrograde lower greenschist-facies

Schist and amphibolite (Early Cretaceous or older)--Hornblende-biotite-quartz-plagioclase schist and hornblende-plagioclase-quartz amphibolite. Derived from gabbro, quartz gabbro, diorite, and quartz diorite. Relict hypautomorphic-granular texture. Ductilely deformed at middle amphibolite facies into mylonitic schist and gneiss. Local retrograde metamorphism to greenschist facies. Relatively older and more highly metamorphosed equivalent of the gneissose granitic rocks of the East

Migmatite (Cretaceous?)--Highly contorted schist and amphibolite with abundant diffuse veins of granodiorite. Gradational unit between the gneissose granitic rocks unit (gg), with fragments of nearly completely assimilated schist and amphibolite, and the migmatitic schist (mgsh). Contorted schistosity. Contains abundant, small to large

Migmatitic schist (Cretaceous?)--Schist and amphibolite with sparse to moderately abundant veins of granitic rock. Attitude of schistosity generally constant over large areas. Gradational unit between schist and amphibolite of the Maclaren Glacier metamorphic belt (mmb) and the

migmatite (mig). Contains fewer dikes of granitic rock Schist, quartzite, and amphibolite (Early Cretaceous or older)--Calc-silicate schist, para-amphibolite, and quartzite. Ductilely deformed and regionally metamorphosed at

amphibolite facies into mylonitic schist. Intruded by the

Maclaren Glacier metamorphic belt

gneissose granitic rocks (gg)

Schist and amphibolite, phyllite, and argillite and metagraywacke (Middle Jurassic or older)--Three-part faulted sequence. Metamorphic grade systematically increases from lower greenschist facies in the south to middle amphibolite facies to the north. Ductilely deformed into protomylonite and phyllonite in the argillite and metagraywacke part of the unit, phyllonite in the phyllite part of the unit, and mylonitic schist in the schist and amphibolite part of the unit. Occurs as a faultbounded unit south of Meteor Peak fault and north of Broxson Gulch thrust. Argillite and metagraywacke part of the unit derived from volcanic graywacke and siltstone, and minor andesite and basalt, with lesser calcareous and quartz siltstone

South of Meteor Peak fault

CLEARWATER TERRANE Within splays of Broxson Gulch thrust

Schistose metasedimentary and metavolcanic rocks (Late Triassic)--Chlorite schist, muscovite schist, and marble; lesser schistose metarhyolite and metarhyodacite flows, and greenstone derived from pillow basalt. Weakly deformed and metamorphosed at greenschist facies. Intensely deformed at faults between units in some areas

WRANGELLIA TERRANE South of Denali fault and Broxson Gulch thrust

Sandstone, conglomerate, and volcanic rocks (late and middle Tertiary)--Interbedded, light-colored sandstone, conglomerate, gray siltstone, shale and mudstone, thin coal beds, rhyodacite ash, rhyodacite and dacite tuff, breccia, agglomerate, flows, dikes, and sills. Commonly occurs as fault-bounded lenses in branches of McCallum Creek-Slate

Tertiary)--Interbedded light-colored sandstone, conglomerate, gray siltstone, shale, and mudstone, coal beds, and thin beds of dacite to rhyodacite flows and tuff. Commonly occurs as fault-bounded lenses in branches of Broxson Gulch thrust, Rainy Creek thrust, and Eureka

McCarthy Formation (Early Jurassic and Late Triassic)--Thinto medium-bedded calcareous argillite and impure imestone with abundant Monotis. Occurs in branches of Broxson Gulch thrust

Gabbro, diabase, and metagabbro (Late Triassic)--Small, irregular bodies, dikes, and sills of medium- to coarsegrained gabbro and fine- to medium-grained diabase, and local schistose metagabbro that occur throughout the hypautomorphic-granular or ophitic aggregates of linopyroxene, plagioclase, and lesser biotite to regionally metamorphosed metagabbro composed of schistose aggregates of hornblende or actinolite, chlorite, biotite, epidote, and albite. In some areas, may be late Paleozoic in age and part of the igneous suite in the Slana Spur Formation (PPs) and Tetelna Volcanics (Pt)

Cumulate mafic and ultramafic rocks (Late Triassic?)--Moderate- to large-sized sills of olivine, olivineclinopyroxene, and clinopyroxene-plagioclase cumulate. Partly to mostly serpentinized. Locally intensely deformed into serpentinite, actinolite-chlorite schist, or talc schist. Occurs as large sills in the Tangle subterrane, and as fault-bounded lenses in the Slana River subterrane

> Slana River subterrane South of Denali fault and Broxson Gulch thrust and north of Eureka Creek fault

Marine sedimentary rocks (Early Cretaceous and Late Jurassic)--Interlayered gray argillite, siltstone, graywacke, pebble conglomerate, and andesite. Abundant graded and rhythmic bedding, sole marks, and slump folds in some areas. Interpreted as deep-marine turbidite deposits.

thick as several meters. Usually ophitic or hypautomorphic-granular with clinopyroxene, plagioclase, and magnetite. Generally regionally metamorphosed and

locally schistose with abundant metamorphic actinolite. epidote, chlorite, albite, and sericite. Quartz veins and altered zones with copper-sulfide minerals in some areas Eagle Creek Formation (Early Permian)--Argillite and limestone. Argillite is dark gray and thin bedded with local calcareous siltstone and thin limestone interbeds. Limestone is light to dark gray and thin bedded to massive with thin argillite interbeds. Chert nodules and thin layers

MISCELLANEOUS FIELD STUDIES

MAP MF—1996–B SHEET 1 OF 3

PAMPHLET ACCOMPANIES MAP

Nikolai Greenstone (Late Triassic) -- Subaerial, amygdaloidal

basalt flows separated by thin beds of nonmarine

volcaniclastic rocks in some areas. Predominantly

intermixed aa and pahoehoe flows. Individual flows as

of chert, volcanic graywacke, and clastic limestone in some areas. Local grading and crossbedding. Pervasively metamorphosed to lower greenschist facies. Locally intensely metamorphosed in some areas near Denali fault Shallow-level intrusive stocks, dikes, sills, and small plutons

(Permian?)--Small- to moderate-size intrusive stocks, dikes, and sills. Mainly dacite with lesser andesite, rhyodacite, and diabase, generally fine grained. Local small plutons of granodiorite and granite. Porphyritic with relict plagioclase phenocrysts in some areas. Weakly schistose in some areas. Pervasively, weakly metamorphosed to lower greenschist facies. Local intense hydrothermal alteration minerals of sericite, chlorite, epidote, actinolite, albite, potassium feldspar, and clay; local iron staining and disseminated sulfide minerals

Slana Spur Formation (Early Permian to Middle Pennsylvanian)--Thick sequence of marine calcareous (upper part) and noncalcareous (lower part) volcaniclastic rocks, and lesser volcanic sandstone, conglomerate, tuff, volcanic breccia and flows, and limestone. Fine- to coarse-grained. Volcanic rock generally dacite and lesser andesite, rhyodacite, and basalt. Medium- to thickbedded. Locally abundant grading and crossbedding. Weakly schistose to massive. Pervasively metamorphosed to lower greenschist facies. Locally abundant iron staining. Disseminated sulfide minerals

Tetelna Volcanics (Pennsylvanian)--Dark-gray-green, fine- to coarse-grained, thin- to thick-bedded andesite and dacite flows, with sparse basalt flows and local volcanic breccia, volcanic graywacke, conglomerate, and tuff. Weakly schistose to massive. Pervasively metamorphosed to lower greenschist facies. Locally abundant iron staining. Disseminated sulfide minerals

> Tangle subterrane South of Eureka Creek fault

limestone to gray and white, medium-grained marble. Thick-bedded to massive. Weakly schistose. Generally pervasively recrystallized. Locally faulted and sheared. Locally metasomatized to skarn near granitic plutons

Limestone (Late Triassic) -- Ranges from gray, fine-grained

Nikolai Greenstone (Late Triassic)

Subaerial basalt flows and minor associated shale, chert, and siltstone. Subaerial, amygdaloidal basalt flows separated locally by thin beds of nonmarine volcaniclastic rocks and local thin beds of shale, chert, and siltstone. Predominantly intermixed aa meters thick. Common ophitic texture or hypautomorphic-granular texture with clinopyroxene, plagioclase, and magnetite. Generally regionally metamorphosed and locally schistose with abundant metamorphic actinolite, epidote, chlorite, albite, and sericite. Similar to the Nikolai Greenstone in the Slana River subterrane (Rn ). Local quartz veins and altered areas contain copper-sulfide minerals

Massive pillow basalt flows, and minor basaltic breccia and tuff, and argillite. Pillow basalt flows are similar to subaerial basalt flows of the Nikolai Greenstone in the Slana River subterrane (Rn ). Weakly schistose to massive. Generally regionally metamorphosed with abundant metamorphic actinolite, epidote, chlorite, albite, and sericite. Local quartz veins and altered areas including copper-sulfides

Aquagene tuff, argillite, limestone, chert, andesite tuff, and greenstone (late Paleozoic)--Interlayered basaltic aquagene tuff, gray siliceous argillite, calcitic limestone and marble, red and black chert, and gray-green tuff and basalt. Medium- to thick-bedded. Weakly schistose to massive. Pervasively metamorphosed to lower greenschist

**EXPLANATION OF MAP SYMBOLS** Contact--Dotted where concealed

Fault--Dashed where approximately located; dotted where concealed; sawteeth on upper plate; teeth indicate dip Anticline or antiform--Showing direction of plunge where

known; dashed where approximately located; dotted where Overturned antiform--Showing direction of dip of limbs; dashed where approximately located; dotted where concealed

Syncline or synform--Showing direction of plunge where known; dashed where approximately located; dotted where

Strike and dip of beds Strike and dip of schistosity

EXPLANATION Patterned areas delineate drainage basins in which anomalously high amounts of the metals shown on the maps were found. Frequencies and TERRANE OF ULTRAMAFIC AND cumulative percents for the metals are shown in tables 1 through 8. The ASSOCIATED ROCKS anomalous levels (weak, moderate, or strong) refer to the relative class or MACLAREN TERRANE Granitic plutons East Susitna batholith Faulted intrusive contact KJg Gabbro to granodiorite plutons LATE JURASSIC Intrusive contact Maclaren Glacier metamorphic belt YUKON-TANANA TERRANE CLEARWATER TERRANE HTY LTY MTY TTH TL, Lake George subterrane YTM, Macomb subterrane Splay of Broxson Gulch thrust YTJ, Jarvis Creek Glacier subterrane ANOMALOUS CONCENTRATION OF WRANGELLIA TERRANE YTH, Hayes Glacier subterrane Nenana Glacier fault AURORA PEAK TERRANE RS. Slana River subterrane WRT. Tangle subterrane Splay of Denal: fault --- ·· Fault--dotted where concealed WINDY TERRANE Splay of Denal: fault

> SUMMARY AND INTERPRETATION OF GEOCHEMICAL MAPS FOR STREAM SEDIMENT AND HEAVY MINERAL CONCENTRATE SAMPLES, MOUNT HAYES QUADRANGLE, EASTERN ALASKA RANGE, ALASKA

Figure 1.--Tectonostratigraphic terrane map of the Mount Hayes

quadrangle, eastern Alaska Range, Alaska.